Ghanaian JSS2 Students' Abysmal Mathematics Achievement in Timss-2003: A Consequence of the Basic School Mathematics Curriculum

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Abstract

In 2003, Ghana for the first time participated in TIMSS in order to find out how the performance of her eighth graders (JSS2) in science and mathematics compared with those of other countries. This paper presents an overview of the performance of the JSS2 students in the TIMSS-2003 in mathematics, with particular reference to the released items. The analysis of the Ghanaian students' performance on the released items indicated that Measurement, Geometry and Algebra were the candidates' weak content areas. The mean percentage of Ghanaian students making correct responses to the released items in Algebra, Measurement and Geometry were 13.6, 17.3 and 13.4 percent, respectively. For Number and Data, the mean percentage making correct responses to the released items were 22.6 percent and 27 percent. The Ghanaian students found the constructed response items more difficult than the multiple-choice items. The mean percentage of students who were able to provide the correct responses to the multiple-choice items was 21.6 percent while that observed for the constructed response items was 12.1 percent.

The paper also presents the results of analyses of Ghanaian mathematics curriculum (textbooks and what teachers taught); and also the BECE-2004 and TIMSS-2003 test items. It was observed that the Ghanaian curriculum places a great deal of emphasis on number and in addition, most (77%) of the items in the BECE elicited responses in the lowest cognitive domain, i.e. 'knowledge of facts and procedures'. The BECE included only few (12.1%) items that required the students to solve routine problems. None of the BECE items can be classified as one that required some higher level reasoning from the students. The TIMSS on the other hand devoted 36 and 21.6 percent of its items to solving routine problems and reasoning, respectively.

It can be argued in this light that the Ghanaian mathematics curriculum does not meet requirements that are currently valued globally in school mathematics. The poor performance is therefore largely a reflection of the nature of school Mathematics curriculum and assessment system that students have experienced in this country in the last three decades. No wonder only 42 percent of Ghanaian JSS mathematics teachers used the mathematics textbooks as the main basis for mathematics lessons. The writers believe that not until Ghana abandons the "*new maths*" schemes which had remained in the nation's schools since 1975 and adopts textbook schemes that offer what is currently valued globally in school mathematics, Ghanaian students' performance in the subject will continue to be abysmally low.

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Introduction

Trends in International Mathematics and Science Studies (TIMSS) 2003 is the third in a series of studies undertaken once every four years by the International Association for the Evaluation of Educational Achievement (IEA) to examine student achievement in science and mathematics, two key curriculum areas that are fundamental to the development of technologically literate societies. TIMSS-2003 seeks to continue to monitor trends in science and mathematics at the eighth grade (JSS2) and at the fourth grade (Primary 4). Ghana's participation in TIMSS-2003 was strategic as it enabled the country to find out how the performance of her eighth graders (JSS2) in science and mathematics compared with those of other countries (Mullis, et al., 2004; Martin, et al., 2004).

In Ghana, TIMSS-2003 involved a total of 5,114 JSS2 students in 150 schools sampled across the country. The mathematics in the official curriculum materials (i.e. the 1987 syllabi and Ghana Mathematics Series textbooks) used by this cohort of JSS students from primary to junior secondary school were the type that were described as 'modern mathematics' in Europe and 'new math' on the other side of the Atlantic (Howson, Keitel, and Kilpatrick, 1981). Though in the 1980s concerns were raised internationally for countries still using the 'new math' textbook schemes to adjust them (Howson and Wilson, 1986), Ghana has been very slow in responding to this concern. While the 1987 syllabi were reviewed and supplied to schools in 2001, two years before the TIMSS study, no matching textbooks have been supplied to schools. This implies that the nature of mathematics experienced by this cohort of JSS2 students hardly meets requirements that are currently valued globally in school mathematics.

This paper presents an overview of the performance of the JSS2 students' achievement on TIMSS-2003 released items in mathematics and examines the relationship between the performance and the *new math* schemes that have remained in the nation's schools for three decades.

TIMSS assessment framework for mathematics

The mathematics assessment framework for TIMSS-2003 was covered by two organising dimensions, a content dimension and a cognitive dimension. There were five content domains: Number, Algebra, Measurement, Geometry and Data. Items in these content domains were designed to elicit the use of particular cognitive skills in four cognitive domains, namely, Knowing Facts and Procedures; Using Concepts; Solving Routine Problems; and Reasoning. The Mathematics Cognitive Domains involved the use of such processes as

- *Knowing facts and procedures*: recall; recognize; compute; use tools.
- *Using concepts*: know; classify; represent; formulate; distinguish.
- *Solving routine problems*: select; model; interpret; apply; verify/check.
- *Reasoning*: hypothesize/predict; analyze; evaluate; generalize; connect; synthesize; solve non-routine problems; justify/prove (Mullis, et al., 2004). .

Below are the main topics that the items covered in the five content domains:

a. *Number (i.e. fractions and number sense)* – includes whole numbers and integers; common and decimal fractions including their meaning and representation, operations, relations and properties, estimation; and proportionality.

b. *Measurement* – includes concepts of measurement, units of measurement, perimeter, area, and volume, and estimation of measurements.

c. *Data (i.e. representation and interpretation of data, and probability)* – includes interpretation of tables, charts, and graphs, and simple descriptive statistics such as means; simple probability concepts and numerical probability.

d. *Geometry* – includes congruence and similarity; transformations and symmetry; coordinate geometry; points, lines, angles, parallels and perpendiculars; polygons (including triangles and quadrilaterals); and circles.

e. *Algebra* – includes linear equations; algebraic expressions and formulas, linear inequalities, simple linear system, and number patterns; setting up and solving simple proportionality *equations* (Mullis, et al., 2004).

Overview of overall achievement in mathematics

Out of the 46 countries that participated, Ghana was second from the bottom of the results table with a mean score far below the international average. The mean mathematics score of 276 and its range (as indicated by the difference between the 5^{th} and 95^{th} percentiles) for JSS2 students are presented in Table 1.

Table 1 JSS2 Students' mean mathematics score in TIMSS-2003

JSS2 students	Mean mathematics scale score
Overall mean	276 (4.7)*
Range (95% confidence interval)	130 - 430

*Standard error in parentheses

[Source: Anamuah-Mensah, Mereku and Asabere-Ameyaw (2004)].

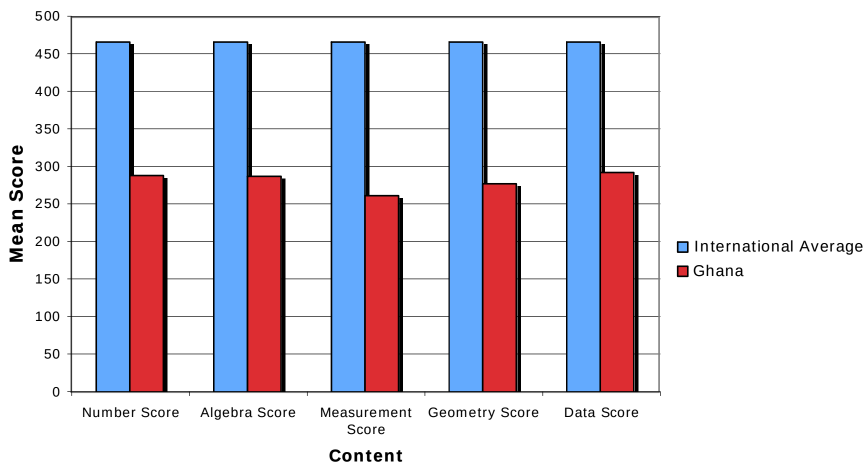
The mean score was significantly low compared to the international mean score of 467. It placed Ghana at the 45^{th} position out of the 46 countries participating in the study. The range of scores from 130 to 430 shows how diverse the JSS2 students were in their mathematics abilities.

The mean percentage correct on all mathematics test items for each participating Ghanaian student was 15 and only 9% and 2% of the students reached the low and intermediate international benchmarks respectively. The performance of the JSS2 students in the TIMSS was unsurprisingly very poor because of the nature of mathematics students were made to experience at school in this country. Analyses of the students' performance on the TIMSS mathematics test items show that the few (about 15%) items for which most students were able to make correct responses were those that were testing knowledge of facts and procedures. They performed poorly on items that tested their ability to use concepts, solve non-routine problems and reason mathematically (Anamuah-Mensah, et al, 2004).

Mean achievement in mathematics content domains

The five content domains listed above constitute independent subgroups with a common reporting metric (or scale) that makes it possible to compare the relative strengths and weaknesses of the students in relation to their performance in the different content domains (or categories). The international mean was placed at 467 for each of the five reporting domains. The mean performance of the Ghanaian JSS2 student in all the five mathematics content areas was as follows: Number, 289; Algebra, 288; Measurement, 262; Geometry, 278, and Data, 293. These mean scores were significantly lower than the international means in each of the content areas and were about 180 scale score points below the international means. It can also be seen from Figure 1 that there was little difference in the achievement of the Ghanaian students in the different mathematics content areas.

Figure 1 Relative strengths of Ghanaian JSS 2 students in the mathematics content areas tested in TIMSS-2003



Ghanaian students' achievement in the mathematics content domains was also compared to those of selected countries[3]. In doing this comparison, note was taken of the different curriculum emphases among the countries, as well as relationships between the test items used in TIMSS-2003 and the curriculum.

In Table 2 achievement in the five content areas for Ghana, five other African countries, England, United States of America, Japan, Chinese Taipei, Malaysia, Singapore and Korea are presented. Ghanaian students' performance was far below that of all selected countries except South Africa, in all content areas. It is noteworthy that in none of the mathematics content areas did students' achievement reach a level where it could be said that they have a relative strength in that area in comparison to other countries. It can be seen from the table that Ghana's average score in Measurement and Data were the lowest of all the participating countries. The average difference in performance between Ghanaian students and students in

[3] The criteria for the selection was based on whether the country had a similar economic and educational status at the time of Ghana's independence, was African, or currently has a strong political and economic ties with Ghana.

the highest performing country, Singapore, is about 310 scale points in all content areas. The African country with the highest mean score in mathematics, Tunisia (410), out-performed Ghana in the five content areas by an average of about 120 scale points. South Africa, whose overall performance was similar to that of Ghana, had a similar relative strength in the five areas to that of Ghana.

Table 2 **Country mean scale scores for mathematics content areas by selected participating countries**

	Number Score	Algebra Score	Measurement Score	Geometry Score	Data Score
Countries comparable to Ghana at Independence					
Singapore	618 (3.5)*	590 (3.5)	611 (3.6)	580 (3.7)	579 (3.2)
Korea	586 (2.1)	597 (2.2)	577 (2.0)	598 (2.6)	569 (2.0)
Chinese Taipei	585 (4.6)	585 (4.9)	474 (4.4)	588 (5.1)	568 (3.3)
Japan	557 (2.3)	568 (2.0)	559 (2.0)	587 (2.1)	573 (1.0)
Malaysia	524 (4.0)	495 (3.9)	504 (4.9)	495 (4.8)	505 (3.2)
African Countries					
Ghana	**289 (5.1)**	**288 (4.8)**	**262 (3.7)**	**278 (4.3)**	**293 (4.1)**
Egypt	421 (3.0)	408 (3.9)	401 (3.3)	408 (3.6)	393 (3.2)
Tunisia	419 (2.3)	405 (2.4)	407 (2.2)	427 (2.0)	387 (2.2)
Morocco	384 (2.7)	405 (2.8)	376 (3.4)	415 (2.3)	374 (2.5)
Botswana	382 (2.3)	377 (2.7)	377 (2.0)	335 (3.9)	375 (2.7)
South Africa	274 (5.4)	275 (5.1)	298 (4.7)	247 (5.4)	296 (5.3)
Countries with strong links with Ghana					
United States	508 (3.4)	510 (3.1)	495 (3.2)	472 (3.1)	527 (3.2)
England	485 (5.0)	492 (4.5)	505 (4.3)	492 (4.5)	535 (4.1)
International Average	467 (0.5)	467 (0.5)	467 (0.5)	467 (0.5)	467 (0.5)

*Standard error in parentheses

Source: (Anamuah-Mensah, et al, 2004).)

Performance on released test items in mathematics

One of the test forms for TIMSS-2003 was released in 2004. The form came with results of students' correct responses to the items. In analysing the released items, the following were taken into consideration: the type of item – multiple-choice and constructed-response, the content domain and the cognitive domain.

Performance on multiple choice and constructed response items

It was observed that 70 percent of the questions in the released items were of the multiple-choice type and the remaining 30 percent were constructed-response items. This was close to the test weightings used in the TIMSS framework, namely, 66 percent multiple-choice and 34 percent constructed-response items. The mean percentage of Ghanaian JSS2 students obtaining correct responses to the released items was 16.9. This was close to the overall mean percentage response on all the 194 items on the mathematics test, which was 15

percent. The mean percentage of students who provided the correct responses to the multiple choice items in the released items was 21.6 percent. This figure was nearly double the percentage observed for the constructed response items, which was 12.1 percent suggesting that the students either found the constructed response items more difficult than the multiple choice items or many of the responses they made to the multiple choice items could have been guess work.

Performance on selected test items in the mathematics content domains

Table 3 shows the percentage of Ghanaian students making correct responses to the TIMSS-2003 released items in the five content categories. It will be observed that students making correct responses to items in the number category ranged between 0.2 and 47.2 percent with a mean of 26.6 percent.

Table 3 **Mean percentage of Ghanians students obtaining correct responses to the released items**

Content domain	Range	Mean
Number	0.2 – 47.2	26.6
Algebra	0.6 – 29.0	13.6
Measurement	0.5 – 39.0	17.3
Geometry	0.1 – 26.0	13.4
Data	2.4 – 48.5	27.0

Even though about 50 percent of the items in the number category elicited responses from the lower cognitive domains – knowing facts and procedures, and using concepts – they were difficult for most Ghanaian children because the items were largely word problems which many of the students had difficulty in solving due to poor reading abilities. Similarly, the percentage of students giving correct responses to released items in the data category ranged between 2.4 percent and 48.5 percent with a mean of 27 percent, making it the content area that most of the JSS2 students were able to respond correctly. The percentage range of students making correct responses to the released items in Algebra, Measurement and Geometry can also be seen in table. It will be observed that these were the content areas that the students found more difficult in the test. There were several items in these content areas that less than 1 percent of the students were able to do correctly.

TIMSS Evaluation of Coverage of the Intended and Implemented Curricula

The teaching syllabus for mathematics recommends that students at JSS2 received 25 percent of the total instructional time. This percentage of the total instructional time allocated to mathematics at JSS2 is the highest compared to all the TIMSS participating countries.

In Ghana no provisions are made in the national curriculum for addressing the issue of students with different levels of ability. That is, there is no differentiation of the content of

the mathematics curriculum to meet the learning needs of groups of students with different levels of abilities. In other words, all students are made to experience the same amount of content in mathematics. This is however not so in many parts of the world today. This is because some of the content found in the curricula at this level, in some educational systems, have been found not to be essential knowledge for ALL, but additional knowledge for students with high abilities who will continue to study the subject in their further education after this level.

In many countries, the national curriculum is not addressing the issue of students with different levels of ability. But the performance of students in countries that address this issue is high. Singapore, where the best results were reported in both subjects, practices even a more extreme form of the differentiation in which the different curricula are used for different groups of students according to their ability level (Mullis, et al., 2004).

In the intended mathematics curriculum, 96 percent of TIMSS topics were expected to be taught to every student. The proportions of TIMSS topics in the five domains of mathematics are presented in Table 4.

Table 4 Percentage of TIMSS topics in Ghana's Intended and Taught Mathematics Curriculum in the five Content domains

Content domain	TIMSS Mathematics topics in Intended Curriculum		TIMSS Mathematics topics actually taught by teachers	
	Ghanaian Students (%)	International Average (%)	Ghanaian Students (%)	International Average (%)
All Topics	96	70	60	72
Number	100	96	83	95
Algebra	100	63	59	66
Measurement	100	78	53	78
Geometry	100	67	51	69
Data	75	39	55	46

Form the table it can be argued that there was no agreement between inclusion of TIMSS topics in the intended curriculum and the coverage of the implemented mathematics curriculum. The students' responses indicate that a good number of topics intended in most content areas were not fully covered. This may be due to the fact that many of the topics in Measurement and Geometry were expected to be taught in the third term of Year 8 (JSS2) and the whole of Year 9 (JSS3). With the exception of Data, the coverage of the mathematics topics was lower than the international average. In this light, it is worthy to note that the countries with high achievement in mathematics in the study also had high coverage of the TIMSS mathematics topics in the classroom (Mullis, et al., 2004).

Comparison of content and cognitive domains emphasised in TIMSS-2003 and BECE-2004

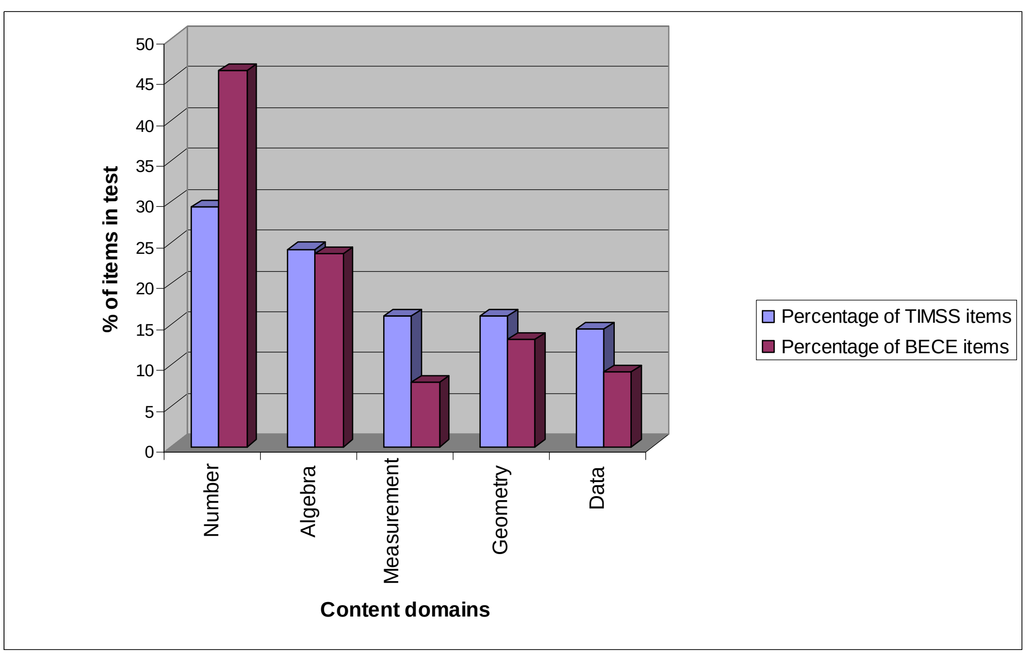
All students in basic education in Ghana write one public examination, Basic Education Certificate Examination (BECE), which is school leaving examination written at end of Year 9 (or JSS3). In this examination, students write papers in at least eight subjects including mathematics. BECE-2004 was taken by the same cohort of students who participated in the TIMSS-2003. While TIMSS-2003 reported that teachers claimed they taught 83 percent of the content under number, the final examination used to evaluate the basic programme, the BECE covered 46 percent of this content domain (see Table 5). That is, nearly half of the BECE items assessed this content area. In the TIMSS however, only 29.4 percent of the items came from this content domain.

Table 5 Emphasis on content domains in curriculum and assessment

Content domain	Percentage of TIMSS items	Percentage of BECE items
Number	29.4	46.1
Algebra	24.2	23.7
Measurement	16	7.9
Geometry	16	13.2
Data	14.4	9.2

There was also a great disparity between the TIMSS and BECE in their emphasis on measurement. Items in this content domain constituted 16 and 7.9 percent in the TIMSS and BECE respectively. Figure 2 shows that generally, besides number, the proportion of items in the other content areas in TIMSS was higher than those in the BECE.

Figure 2 Distribution of Items in TIMSS and BECE Mathematics by Content Domain



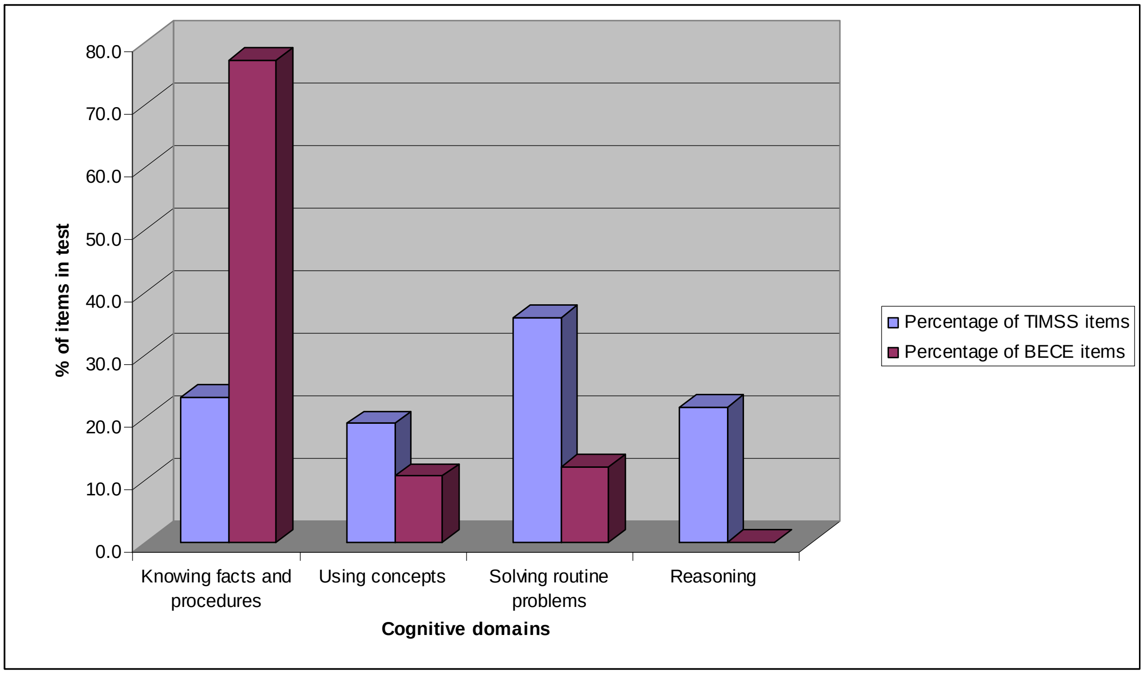
Besides the fact that the Ghanaian curriculum places a great deal of emphasis on number, most (77%) of the items in the BECE elicit responses in the lowest cognitive domain, i.e. ‘knowledge of facts and procedures’. TIMSS had only 23.2 percent of items in this domain. A comparison of the other three cognitive domains shows differences between the BECE and TIMSS items. Table 6 shows the distribution of items in TIMSS and BECE Mathematics by cognitive domain

Table 6 Distribution of items in TIMSS and BECE Mathematics by cognitive domain

	Percentage of TIMSS items	Percentage of BECE items
Knowing facts and procedures	23.2	77.3
Using concepts	19.1	10.6
Solving routine problems	36.1	12.1
Reasoning	21.6	0

It is obvious from the table that there were differences in the proportion of items set in the cognitive domains. The BECE included only few items that required the students to solve routine problems. None of the BECE items can be classified as one that requires some higher level reasoning from the students. While the TIMSS devoted 36 and 21.6 percent of its items to ‘solving routine problems’ and ‘reasoning’ respectively, the BECE devoted only 12.1 percent to solving routine problems and did not include any item that tested reasoning. Figure 3 shows that besides knowing facts and procedures, the proportion of items in the other cognitive domains in TIMSS was higher than those in the BECE and the former emphasised problem solving.

Figure 3 Distribution of Mathematics Items by Cognitive Domain



Discussions

The poor performance of the Ghanaian students can be attributed largely to the lack of congruence between what is emphasized in the mathematics curriculum in Ghana and what is currently valued globally in school mathematics which the TIMSS was designed to measure. The Ghanaian curriculum – textbook, syllabus and assessment – experienced by the students, who participated in the TIMSS-2003, placed a great deal of emphasis on number work and knowledge of facts and procedures.

It can be argued from the above analyses that the poor performance of the Ghanaian students in the TIMSS-2003 is largely a reflection of the nature of school mathematics curriculum that students have experienced in this country in the last two decades. The content of the textbooks and examinations continue to be dominated by commonalities of "*new math*". In fact Ghana is the only nation in the world today that has not moved its mathematics curriculum away from positions adopted in the 1960s.

But according to Fujita and Jones (2003) various studies, including the TIMSS have demonstrated that textbooks, together with documents for use in classrooms as teaching aids, such as resources for exercises, remain important tools in today's classrooms. TIMSS 1999 report indicate that textbooks play an important role in shaping the curriculum experiences of mathematics pupils in the five to 14 age range. This is particularly apparent in the first few years of formal education, since teachers are usually generalists, rather than mathematics specialists (IEA, 2001). In their study of textbooks in TIMSS countries, Valverde et al (2002) considered that textbooks mediate between intended and implemented curriculum and, as such, are important tools in today's classrooms.

The official mathematics schemes currently being used in Ghanaian basic schools, the Ghana Mathematics Series (GMS) textbooks and Teacher's Handbooks (CRDD, 1986, 1987) were products of the West African Regional Mathematics Programme. The series for primary schools were first published between 1975 and 1977 by the Ghana Ministry of Education. Although the manuscripts for the junior secondary books were completed as early as 1977, the books could not be printed until in 1987. The primary books were revised around the same period and this resulted in two major changes (Mereku, 1995). Firstly, it led to the inclusion of more instructions and explanations in the pupil's books. Secondly, the topics were aligned with those in the teacher's handbooks. The revision of the texts did not therefore bring about much change in the content, pedagogy and the complexity and quantity of new math language at the various levels of the scheme.

The new math curriculum materials including the GMS used in Ghana for three decades have been criticised for a number of reasons (Hawes, 1979; Wilson, 1992; Aldrich, 1969). These include criticisms that, (a) the contributors were dominated by academics who were not involved in school teaching; (b) the materials were directed primarily at students of high ability and hence the level of, and complexity of, language of the materials developed were too difficult for most students to understand; and finally, (c) the materials put a great deal of emphasis on the structures of mathematics and the use of precise mathematical language (particularly descriptive terminology) making it difficult for teachers to include enough learning tasks that would allow students to learn the use and applications of the subject.

But in spite of these criticisms, and the concern raised internationally for developing countries to "reconsider and make adjustments to the traditional mathematics curriculum – a phrase used in this context to embrace the 'new math' curriculum – (Howson and Wilson, 1986:14), the GMS schemes have since remained in the nation's basic schools without a supplement. Therefore it did not come as a surprise when the report of a study commissioned by the Ghana Ministry of Education in 1993, pointed out that mathematics teaching in basic schools focuses on computation skills, learning of formulas, rote practice and teaching as telling. The principal investigator in this study, Kraft (1994:2) argued that

> the current syllabi, textbooks and teachers' handbooks do not meet the highest international standards, nor the current best thinking on sequence, learning and pedagogy and will not prepare Ghanaian students for the needs of the next century.

Conclusion

The limitations of the textbooks and the BECE discussed above point to the fact that the basic mathematics curriculum and the assessment processes that has remained in our schools for nearly three decades have little to offer the majority of pupils, particularly those who will not continue to learn mathematics after junior secondary. Anamuah-Mensah, et al (2004) observed that only 42 percent of Ghanaian JSS mathematics teachers used the mathematics textbooks as the main basis for mathematics lessons while 54 percent used it as a supplementary resource. Thus, the textbooks were used mainly by Ghanaian teachers as a supplement to other materials that teachers may have in their possession. This was not the case in most of the high performing countries such as Singapore, Korea and Japan, where the textbooks were the primary materials used in teaching the subject.

For effective learning, textbooks are very essential. Without good textbooks students will have little opportunity to engage in activities that will enable them to use concepts, solve problems and reason mathematically. The Curriculum Research and Development Division (CRDD) of the GES produces teaching syllabuses with specifically developed or recommended instructional activities, which are supplied to all schools. Even though the new teaching syllabuses in mathematics were supplied to schools in 2001, textbooks that match these syllabuses are yet to be supplied to schools four years after the syllabuses were reviewed.

Preparation is underway for the next TIMSS, which comes off in 2007. This is two years from now. In order to ensure there is improvement in the students' performance in the next TIMSS, the Ministry of Education and Sports should make available as soon as possible recommended textbooks and teacher's handbooks that match the revised syllabuses for mathematics. The Ministry of Education's new textbook policy, which provides schools with variety of textbooks on the same subject from different publishers, should also be vigorously pursued.

The GES, in collaboration with Mathematical Association of Ghana (MAG) and the teaching universities, should provide in-service education and training (INSET) for mathematics teachers on test development. The INSET should provide skills in construction of mathematics tests, especially multiple-choice and constructed response tests, to ensure most items in tests demand higher cognitive abilities – solving routine problems and reasoning. The BECE should also be revised to place appropriate emphasis on the various mathematics content and cognitive domains.

References

Aldrich, J.L. (1969). "Thoughts on a cross-national program: African Education Program". Reproduced in Wilson, B. (1981), ***Cultural contexts of Science and Mathematics Education***, Leeds: University of Leeds, Centre for Studies in Science Education.

Anamuah-Mensah, J., Mereku, D. K. and Asabere-Ameyaw, A. (2004) ***Ghanaian Junior Secondary School Students' Achievement in Mathematics and Science: Results from Ghana's participation in the 2003 Trends in International Mathematics and Science Study***, Accra: Ministry of Education Youth and Sports.

CRDD - Curriculum Research and Development Division of GES, (1986) ***Ghana Mathematics Series: Primary Pupil's Book 1-6***. (2nd edition) Accra: Ghana Publishing Corporation.

CRDD - Curriculum Research and Development Division of GES, (1987) ***Ghana Mathematics Series: Junior Secondary Schools Pupil's Books 1-3*** Accra: Ghana Publishing Corporation.

Fujita T. and Jones K. (2003). The place of experimental tasks in geometry teaching: Learning from the textbook designs of the early 20th century', in Pope, S. and McNamara O. (eds.) ***Research in Mathematics Education Volumes: Papers of the British Society for Research into Learning Mathematics***. London: British Society for Research into Learning Mathematics

Hawes, Hughes (1979). ***Curriculum Reality in African Primary Schools***, Bristol, England: Longman.

Howson, A.G., Keitel, C. and Kilpatrick, J., (1981). ***Curriculum Development in Mathematics, Cambridge*** : Cambridge University Press.

Howson, G. and Wilson, B. (1986) ***School Mathematics in the 1990s,*** Cambridge: Cambridge University Press,pp21.

International Association for the Evaluation of Educational Achievement –IEA- (1999) ***Trends in Mathematics and Science Achievement around the World***. http://timss.bc.edu/timss1999.html

International Association for the Evaluation of Educational Achievement –IEA- (2001) ***TIMSS 1999 Benchmarking report***, http://times.bc.edu/timss1999b/mathsbench_report/

Kraft, R. J. (1994) ***Teaching and learning in Ghana: a curriculum, textbook, syllabus and handbook analysis.*** Accra, Ghana: Ministry of Education.

Martin, M. O., Mullis, I. V. S., Gonzalez, E. J., and Chrostowski, S. J. (2004). ***TIMSS-2003 International Science Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades***, Chestnut Hill, MA: Boston College

Mereku, K. D. (1995) ***A comparison of the official primary mathematics curriculum in Ghana with the way in which it is implemented by teachers***, University of Leeds: School of Education. (Ph.D. Dissertation).

Mullis, I. V. S., Martin, M. O., Gonzalez, E. J., and Chrostowski, S. J. (2004). ***TIMSS-2003 International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades***, Chestnut Hill, MA: Boston College

Valverde, G. A. et al (2002) ***According to the book: Using TIMSS to investigate the translation of policy into practice through the world of textbooks.*** Dordrecht: Kluwer.

Wilson, B.J., (1992). "Mathematics Education in Africa", In R. Morris (ed.) ***Studies in Mathematics Education,*** Paris: UNESCO pp125-147.